# Mating disruption of Douglas-fir tussock moth one and two years after the application of pheromone

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## ABSTRACT

Mating disruption of the Douglas-fir tussock moth, *Orgyia pseudotsugata* was monitored in 15 plots, near Keremeos, B.C. in 1993, one and two years after treatment with a synthetic pheromone, *Z-6-heneicosen-11-one.* Six plots were aerially treated, 3 were treated from the ground and 6 received no treatment. Total male moth catches from both the ground- and aerially-treated plots were significantly reduced, compared with control plots, when a synthetic pheromone was used as bait. However when virgin females were used as bait, only the ground treatment was significantly different from the control and only for one year after treatment.

**Key words:** tussock moth, Lymantriidae, biological control, mating disruption, *Orgyia,* pheromone

## INTRODUCTION

The Douglas-fir tussock moth *(Orgyia pseudotsugata* McDunnough*)* occurs in outbreak numbers approximately every ten years (Shepherd *et al.* 1985) and these outbreaks are usually in the same geographical area. The outbreaks last from 1 to 4 yr and can cause complete defoliation of Douglas-fir (*Pseudotsuga menzeisii ssp. glauca* (Beissn.) Franco). Since 1989, the Forest Insect and Disease Survey of the Canadian Forest Service has monitored Douglas-fir stands with known history of tussock moth outbreaks, thus providing an early warning system of impending outbreaks. We have used this monitoring system since 1991 to plan early treatment of stands with *Z-6-heneicosen-11-one,* the tussock moth's sex pheromone. A synthetic pheromone was applied in polyvinyl chloride (PVC) beads, 250 to 400 μm diameter (Hulme and Gray 1994) to Douglas-fir forests near Keremeos, B.C. During the year of treatment this technique of mating confusion is highly effective in reducing the number of fertile eggs without detrimental effects on the parasites that attack Douglas-fir tussock moth (Daterman 1990). Sower *et al.* (1990) reported that traps baited with synthetic pheromone caught few moths one year after plots were treated with pheromone-filled black hollow fibres. The object of this study was to see if synthetic pheromone applied in polyvinyl chloride beads continued to confuse male Douglas-fir tussock moths one and two years after application.

## MATERIALS AND METHODS

Applications of synthetic tusssock moth sex pheromone were made to 3 plots in 1991 and 6 different plots in 1992. In 1991, the larval density was determined by beating three lower branches on each of 20 trees from random locations in each plot. Densities ranged from 4.2 to 27.3 larvae/plot (Shepherd 1985). Three plots: Winters Creek (3.9 ha), Larcan Creek (2.2 ha) and Shoemaker Creek (1.6 ha) were treated with *Z-6-heneicosen-11-one* at 36 g/ha. The application was by a Bell 206 helicopter equipped with a "Simplex" boom and nozzle spray system (Shepherd and Gray 1992). The D-6 nozzles were calibrated to produce a spray swath of 20 m on the ground. The spray mixture contained, 0.2% adjuvant (Nalco-Trol), 0.1% surfactant (Triton B-1956), 2.0% latex sticker (Gelva RA-1990), 97.7% water and pheromone-impregnated PVC beads. They were measured out for each plot at a mixing site before being added to the helicopter's holding tanks and applied on August 2, 1991. Cocoons marked with flagging tape were also monitored, by observing whether or not the wingless female had emerged, weekly from August 5 to September 10 to determine if mating had occured.

In 1992, six 2-ha plots, different from those used in 1991, were treated with *Z-6-heneicosen-11-one* at 72 g/ha. Three plots were treated aerially and three from the ground. Larval densities were determined as for 1991. There was no significant difference in the mean number of larvae between treated and control plots ($p > 0.05$, $\chi^2 = 8.9$; plot mean = 82 SD = 9). Aerial application was by a Hiller UH12E helicopter equipped with a boom and nozzle spray system using D-6 nozzles calibrated to produce an 18 m spray swath on the ground. A ground application was made to the other three plots with a Grinder sprayer Model PS 325-3 (W-W Grinder, Kansas City, KA) with a 30 m hose and a D-6 nozzle. The sprayer was driven through the stand in the back of a 4 x 4 pickup truck. Each host tree was sprayed for approximately 5 s to a height of approximately 10 m. The mixture contained the same ingredients as the 1991 spray. Mixture components were measured for each plot in the laboratory and mixed at the spray site before adding them to the helicopter's holding tanks or the Grinder sprayer. They were all applied on 30 July 1992.

In 1993, the monitoring program after treatment consisted of 6 plots left as untreated controls and of the remaining 9 plots, three which were sprayed in 1991, and six in 1992. Sticky delta milk carton traps, with three sides providing a total trapping surface of 855 $cm^2$, were baited with the synthetic pheromone, in a polyvinyl chloride rod 3 mm diam x 5 mm long, (Daterman 1974) at the rate of 0.01% wt/ wt, similar to that produced by an unmated female. Ten traps with synthetic bait were set out in each plot from August 10 to October 28. Traps were placed 1.5 to 2 m above ground in trees and spaced 40 m apart. Traps that caught 15 or more male moths were replaced with new traps but the old lure was reused. Trap catches were counted and recorded weekly. Each plot also contained ten sticky delta milk carton traps, each baited with a virgin female confined in 30 dram pill vials with insect screening at each end. These traps were hung in a similar pattern to the synthetic pheromone baited traps. Female pupae were held in the laboratory in Victoria, B.C. at three different temperatures to provide fresh, actively-calling females for the duration of the field tests. The calling period of unmated females is usually from 3 to 5 days after eclosion and therefore caged females in field traps were replaced weekly, if emergence had occurred.

Larval densities (beating samples per treatment) were analyzed by a chi-square test (Zelen and Severo 1964). Male moth catches were grouped by treatment and subjected to a Kruskal-Wallis test and each pair of the group was tested for significance between treatments using a Mann-Whitney test (Wilkinson 1992).

## RESULTS AND DISCUSSION

**Pheromone-baited trap catches.** The efficacy of the application of pheromones to control insects is usually measured in the year of application and residual effects are seldom measured. Although different concentrations of synthetic pheromone were applied, 36 g/ha and 72 g/ha in 1991 and 1992 respectively, both were considered sufficient by the authors to disrupt the mating processes of the tussock moth (Hulme and Gray 1994). Significantly more male moths were trapped with synthetic baits in the control plots one year after treatment than in either the ground- or aerially-treated plots (Fig. 1A).

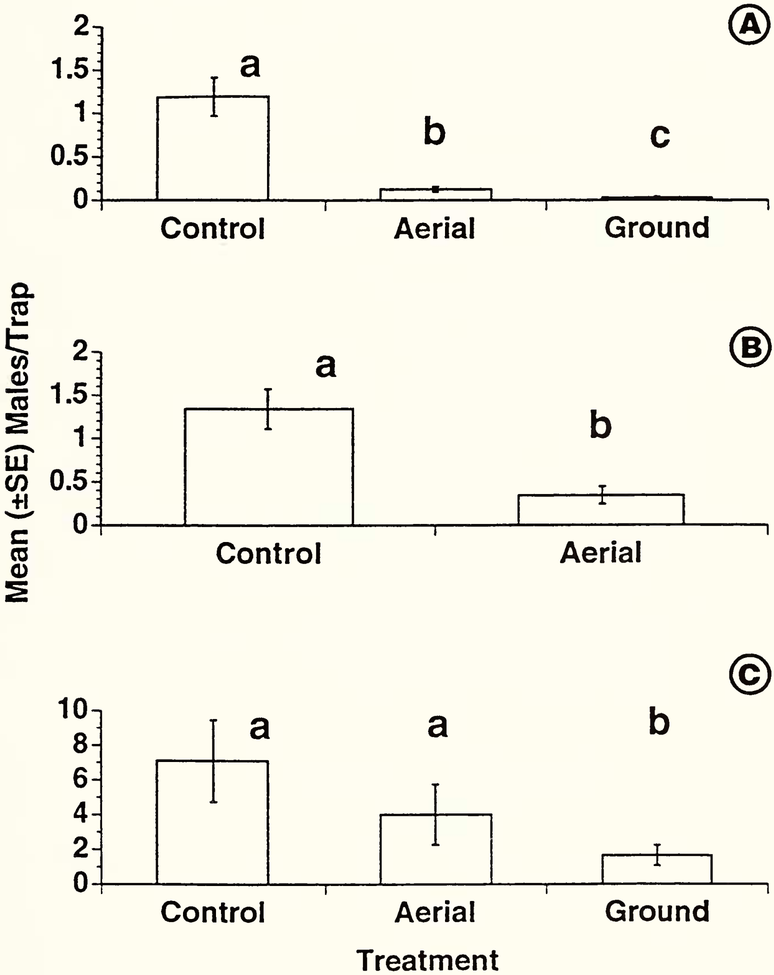


**Figure 1.** Mean number of male Douglas-fir tussock moths, *Orgyia pseudotsugata*, per trap caught in delta sticky traps at Keremeos, B.C., 1993 after treatment with synthetic pheromone. Means having different letters are significantly different ($p<0.05$). A) One year after treatment, synthetic lures (n=150); B) Two years after treatment, synthetic lures (n=150); C) One year after treatment, unmated female lures (n = 23)

Male moth catches in the control plots were also significantly higher than those from the aerially-treated plots two years after treatment (Fig.1B). We did not treat any plots from the ground in 1991, and were therefore unable to determine the two-year residual effect of a ground treatment. Results suggest the beads continued to emit enough pheromone to impair some of the males ability to find the pheromone-baited traps. The results may indicate that less synthetic pheromone was being emitted from the aerially-applied beads than from ground-applied beads one year after treatment. Different distribution of the beads probably explains why. The ground spray was applied up the tree trunks and was probably protected from degradation by the sun, and less exposed to wind, rain and snow then the aerially-applied treatment where most beads were probably on exposed foliage.

**Effect on trap catches using virgin females.** The female-baited traps caught significantly more males in the control than in the ground-treated plots one year after treatment but there was no significant difference between the controls and the aerially-treated plots (Fig. 1C). These results suggest that virgin females are more attractive to males than *Z-6-heneicosen-11-one*. Hulme and Gray 1994 also found female baited traps to be more attractive to males than the synthetic pheromone baited traps. These results are partly explained by our knowledge that the synthetic lures lack minor components of the pheromone.

**Impact of continued pheromone release on pest management.** Results showed that the beads continue to emit pheromone for at least two years after application but that the release of pheromone was probably reduced. The pheromone released from ground applied beads after one year was sufficient to reduce trap catches to near zero with either synthetic pheromone or female baits. Extensive natural disruption of mating would thus be expected in these ground-applied plots. Although trap catches in the aerially-applied plots were reduced by over 50% one year after application, many moths were still caught in most traps, particularly those baited with virgin females. Thus while pheromone continued to be released in our tests it seems unlikely that natural mating would be severely disrupted. Our results confirm that pheromone applied in beads can continue to confuse males as shown by the reduced trap catches for one and two years after treatment.

Although we were able to achieve 100% mating disruption of tussock moths (Hulme and Gray 1994) using high dosages, the cost of pheromome was also high. We will report later on studies using reduced dosages of pheromones which makes this type of treatment more cost effective.

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